

# Colorado climate variability and recent trends

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Colorado

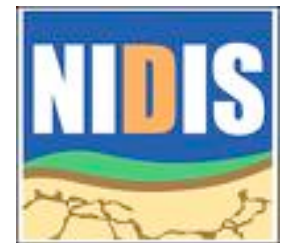


**Colorado Water  
Conservation  
Board**



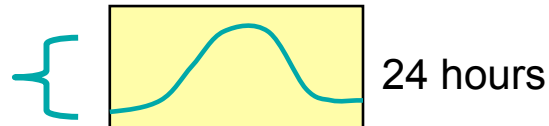
**Colorado**  
University of Colorado at Boulder

**Colorado  
Climate  
Center**

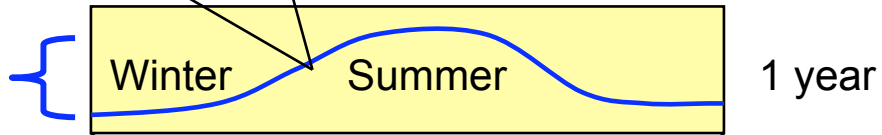


# Time scales of weather and climate variability

Daily



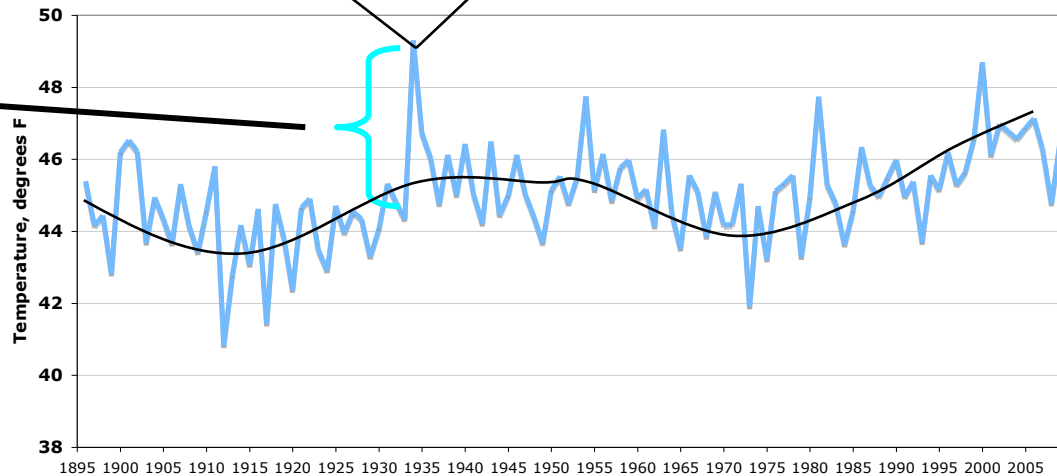
Seasonal



*Very predictable!*

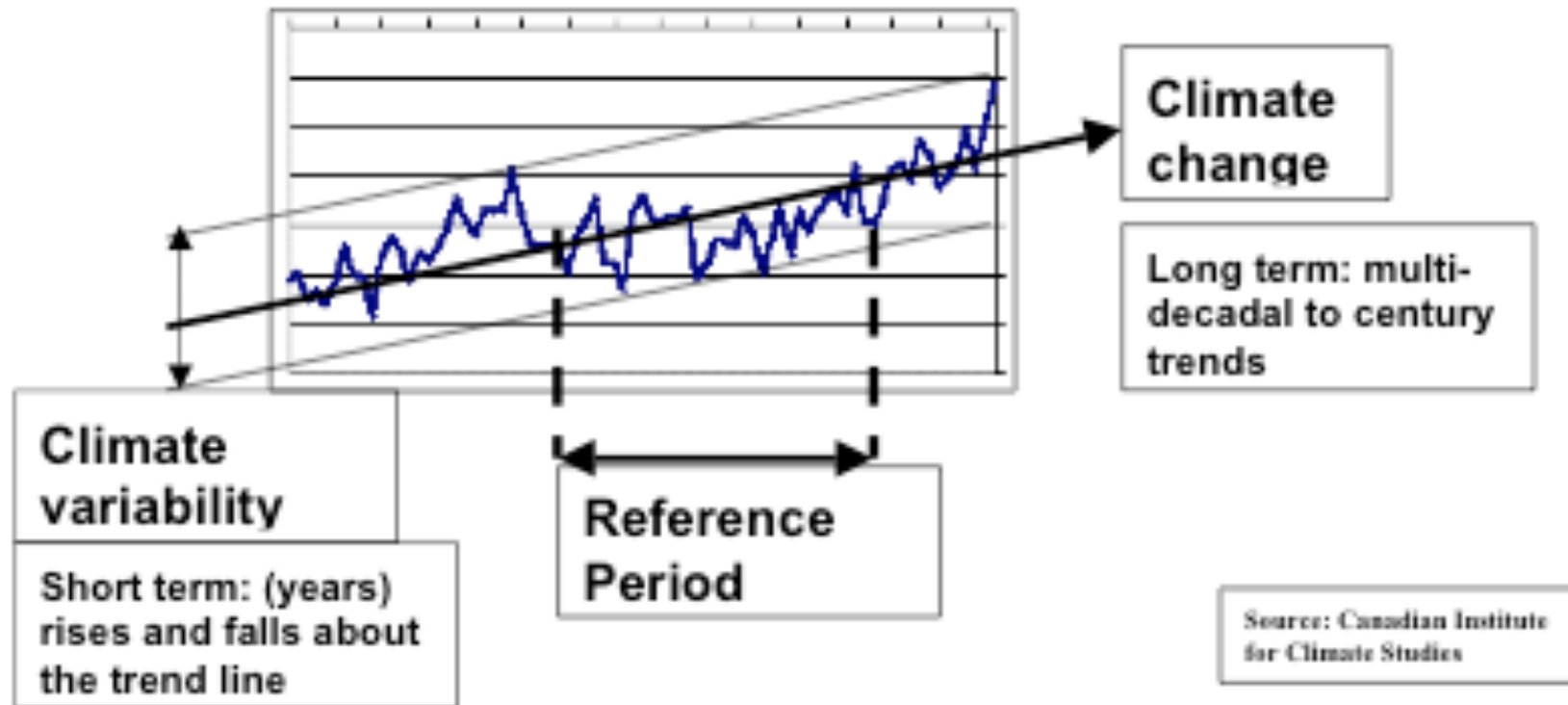
Year-to-year

Decadal

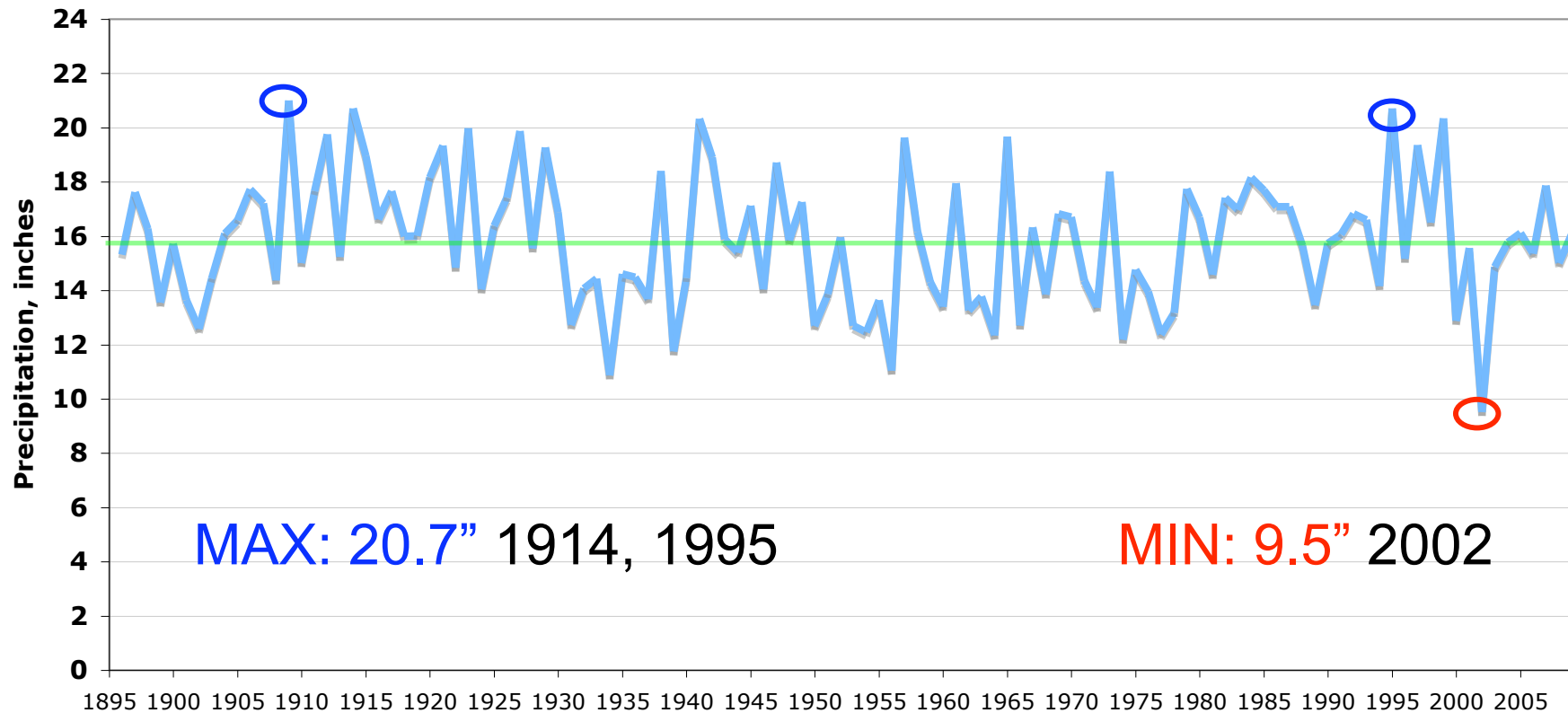


*Much less  
predictable!*

# Climate Variability versus Climate Change



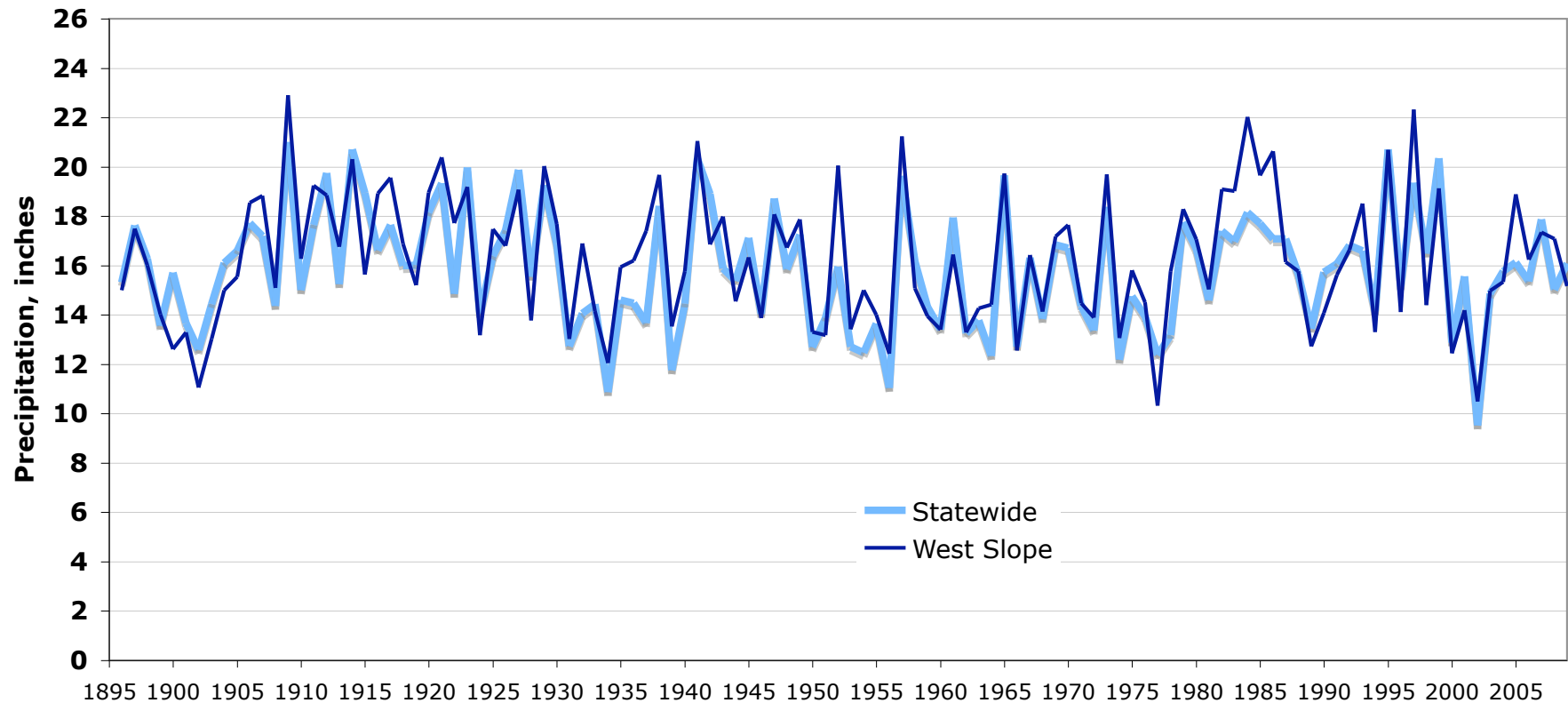
## CO Statewide water year precipitation, 1896-2009



Large year-to-year variability - departures of +/- 30% of mean are common

Also decadal-scale variability (e.g., wet 1920s, dry 1930s)

## CO Statewide water year precipitation, 1896-2009



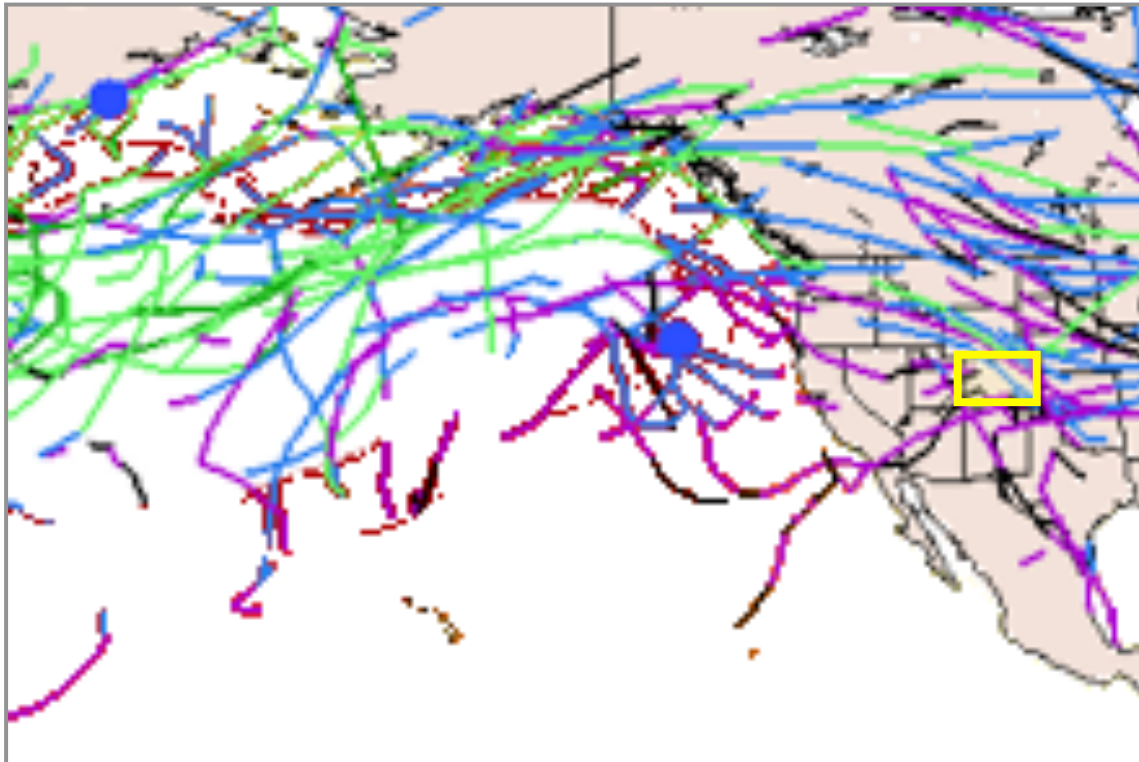
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## Sources of year-to-year precipitation variability

- Most moisture comes from Pacific Ocean in relatively few storms, so position of jet stream and westerly storm tracks is critical
- Summer monsoon flow also highly variable
- Certain features of the climate system *tilt* the odds of storm tracks affecting Colorado, and the strength of monsoon
  - ENSO (El Nino, La Nina) is the most consistent of these influences

## Storm tracks over the Pacific and Western North America, Nov 2008 – Feb 2009

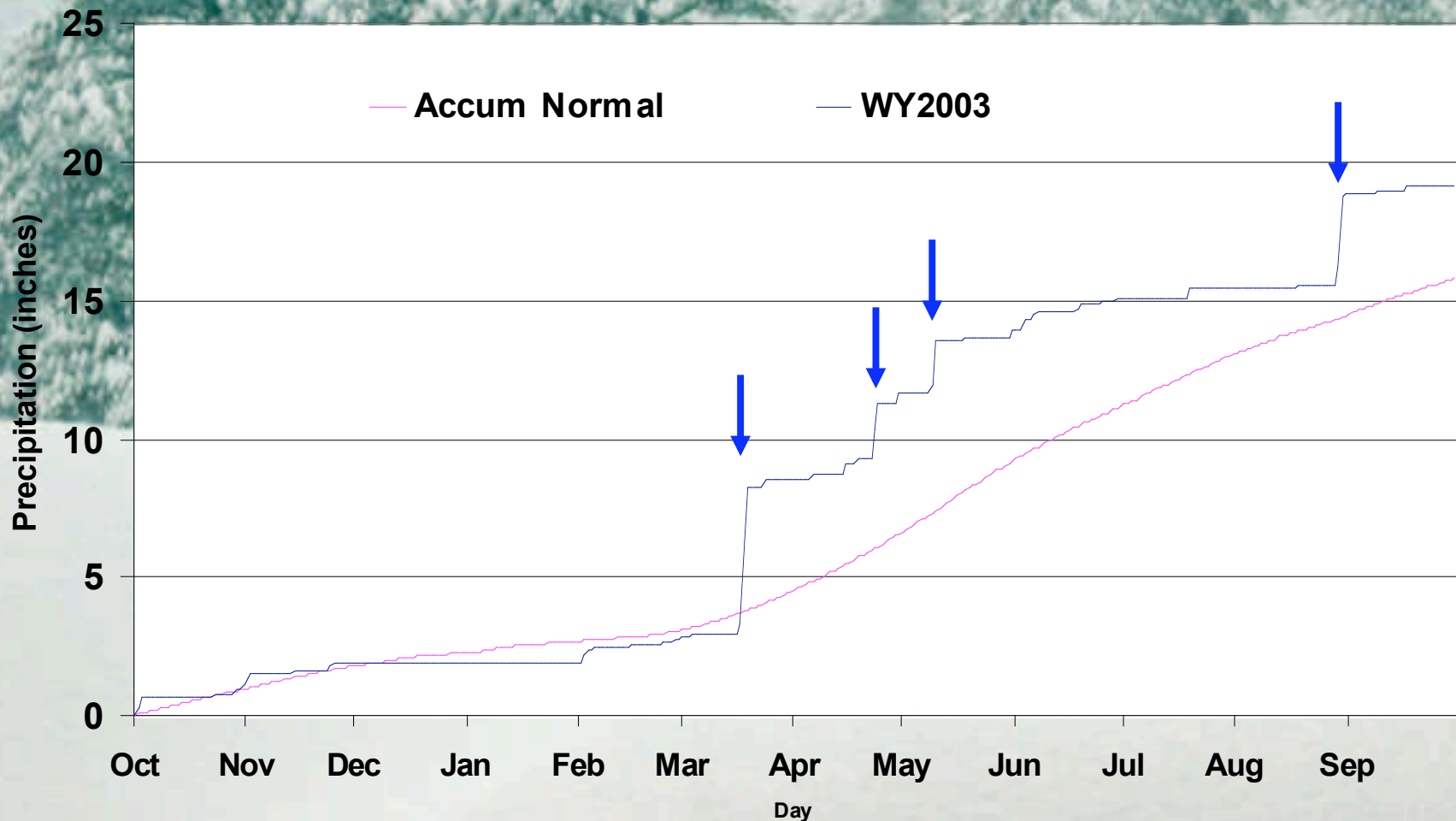


- About a dozen storms impacted Colorado in a 3-month period
- Note how few storm tracks south of Colorado

While individual storm tracks can be forecasted up to a week ahead, their locations over a season are highly random

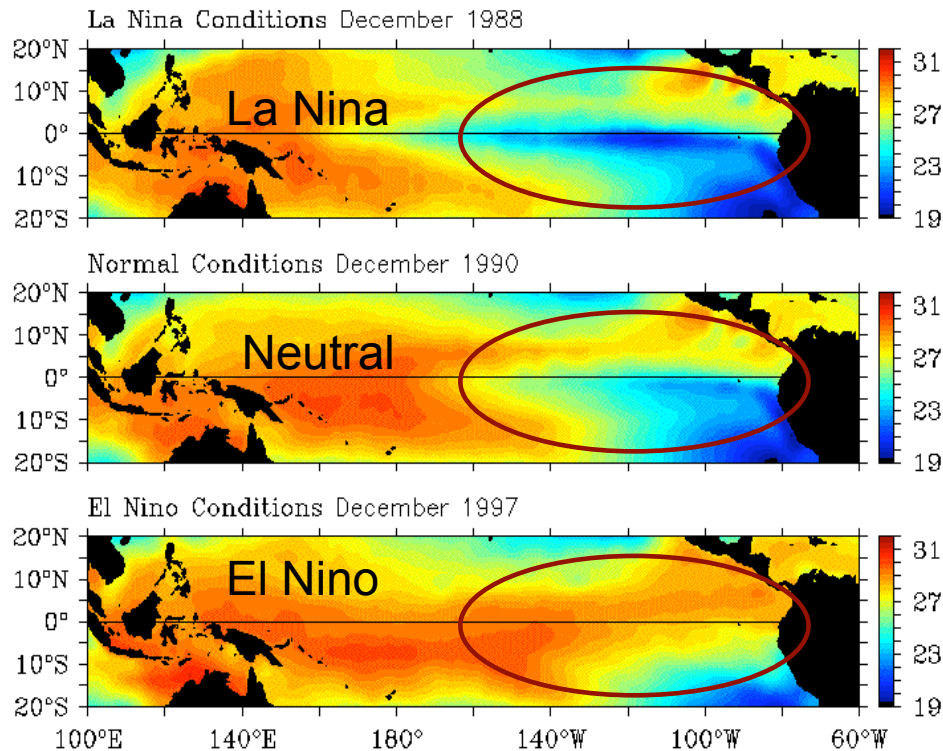
A few storms contribute a large fraction of the annual precipitation in many years

Fort Collins Daily Accumulated Precipitation



# What is ENSO?

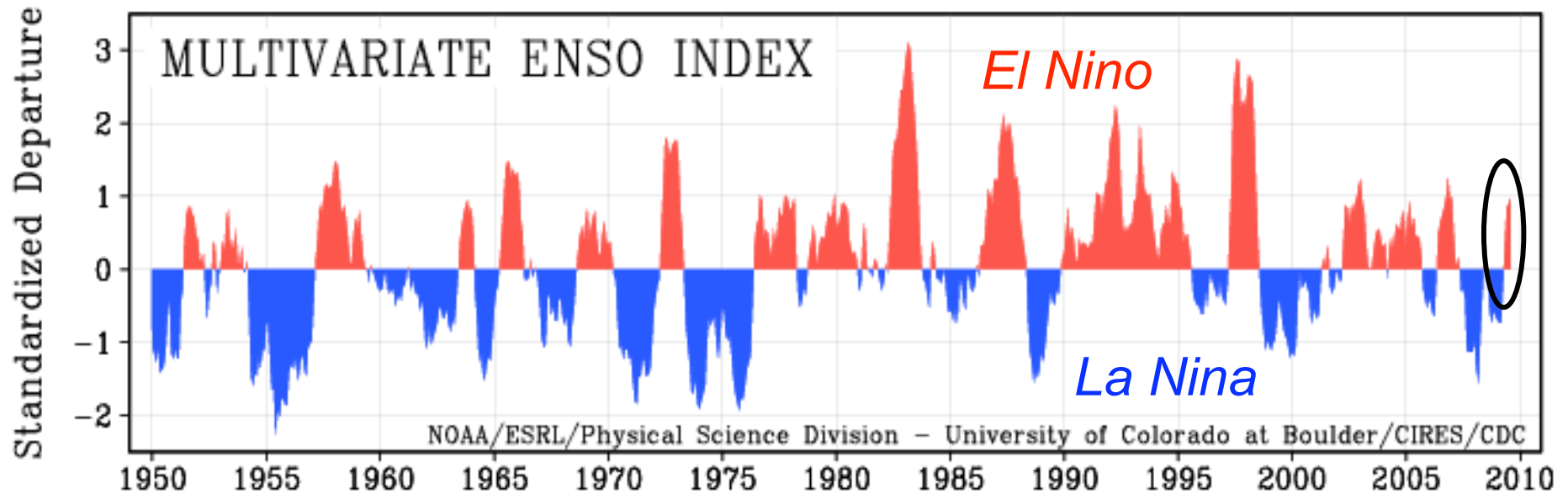
## Reynolds Monthly SST ( $^{\circ}\text{C}$ )



TAO Project Office/PMEL/NOAA

- ENSO events are indicated by sea surface temperature (SST) shifts in the tropical Pacific...
- And large-scale atmospheric circulation changes with many far-flung effects (teleconnections)
- One such effect is the nudging of storm tracks that reach the western US

## Multivariate ENSO index, 1950-2009

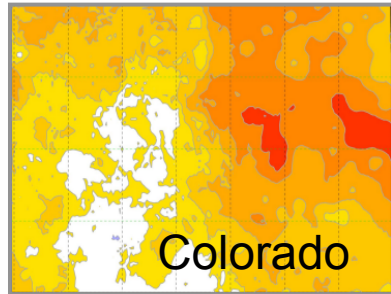


ENSO = “quasiperiodic”

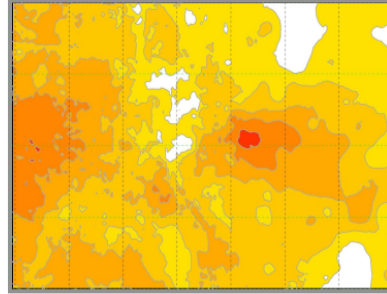
Events typically last 1-3 years; recurrence interval is 4-7 years...we just switched from La Niña to El Niño

Difficult to forecast state of ENSO more than 6-9 months ahead

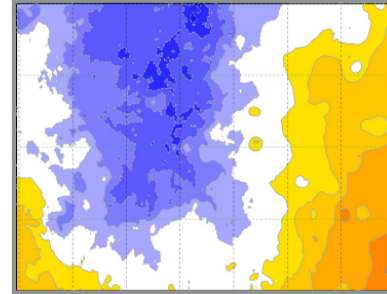
## ENSO “Footprint” on Colorado Precipitation



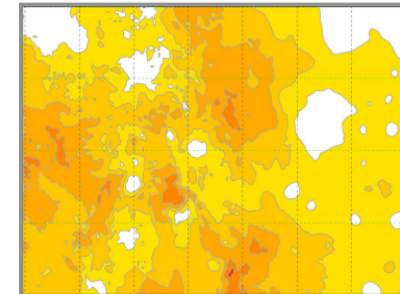
**Summer**



**Fall**



**Winter**



**Spring**

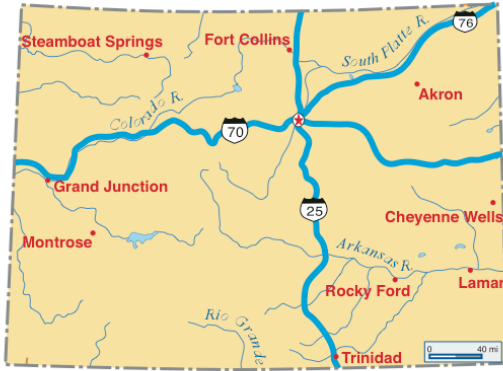
**Orange/Red** = Seasonal precip. tends higher with ***El Nino***

**Blue** = Seasonal precip. tends higher with ***La Nina***

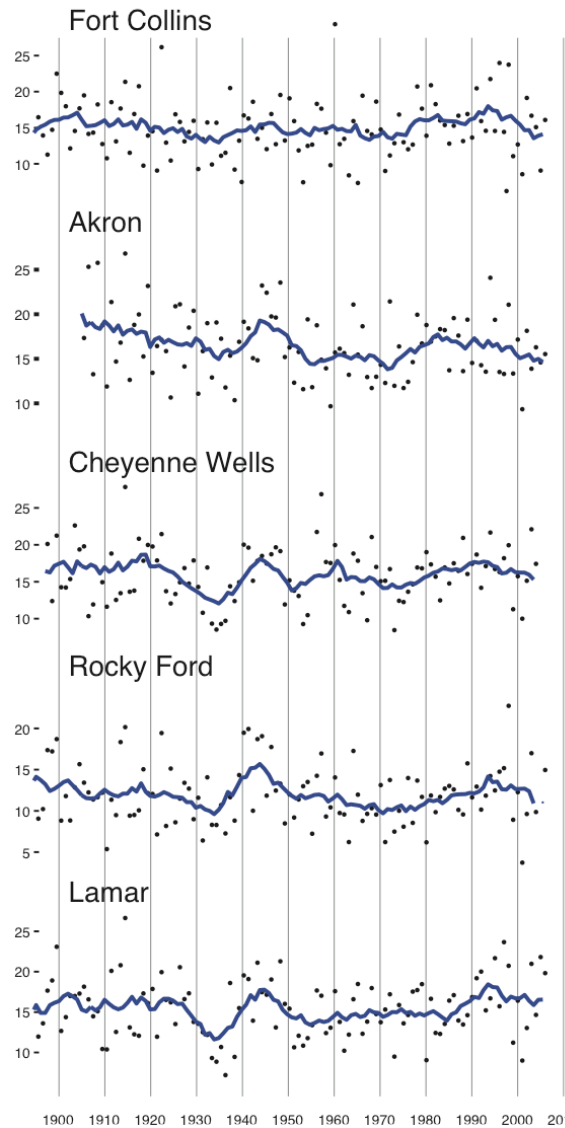
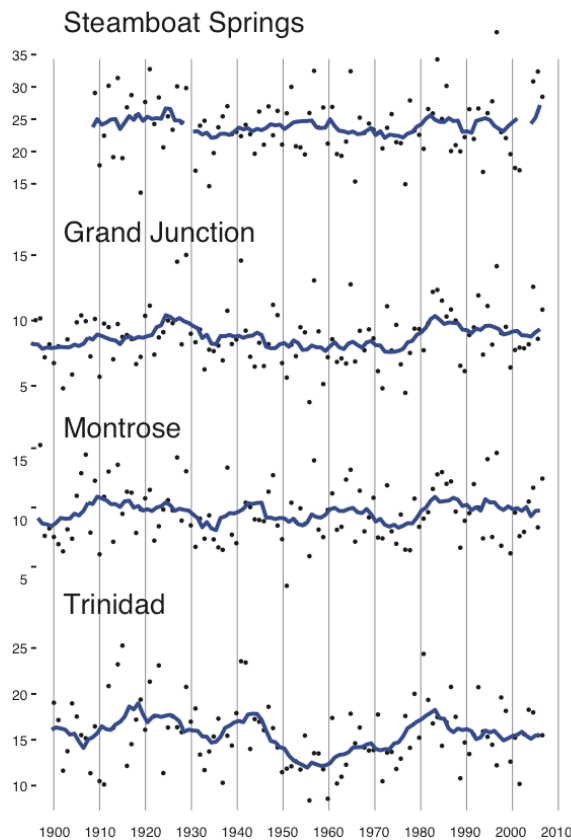
Summary: El Nino tilts Colorado towards wetter conditions in all seasons except winter in mountains

BUT this is a *tendency*, not destiny!

# Observed Trends: Precipitation



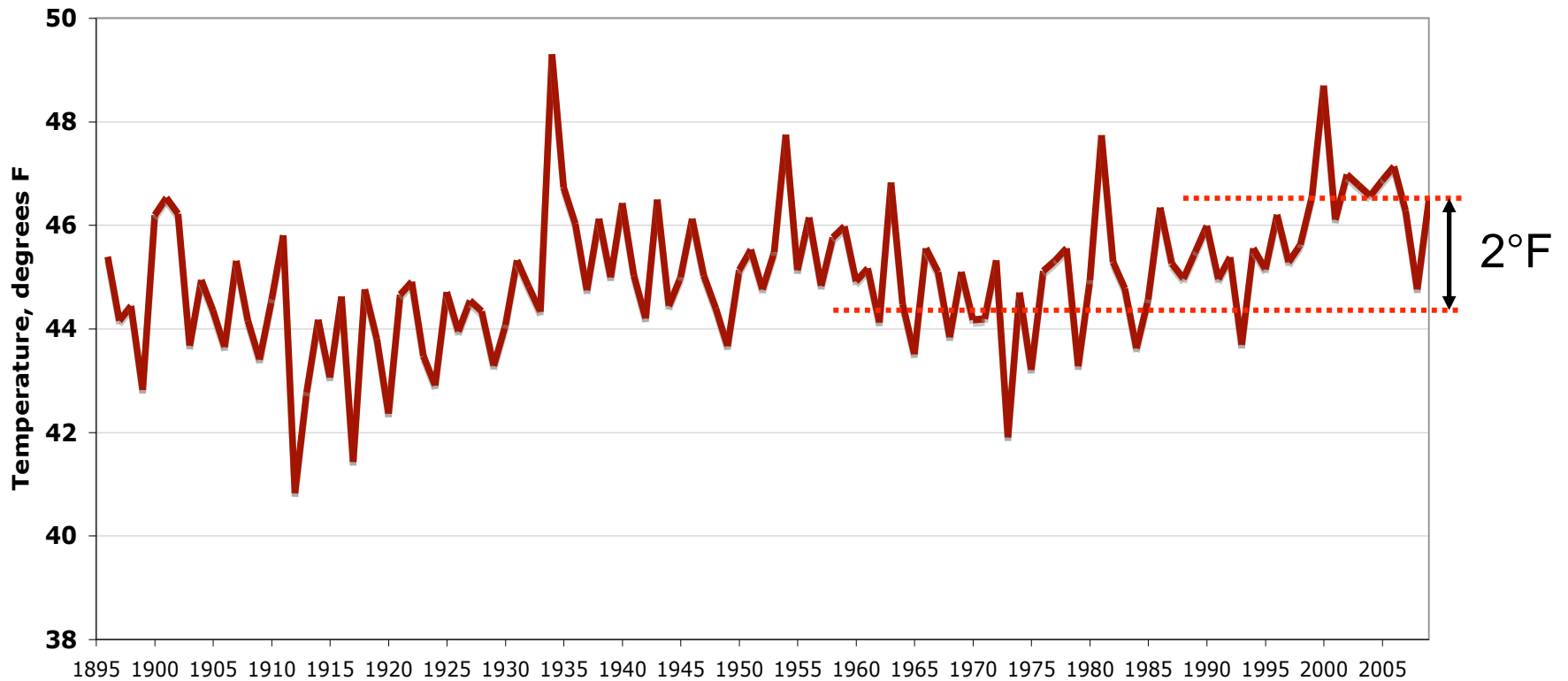
Source: CO Climate Report, 2008



In all parts of Colorado, no consistent long-term trends in annual precipitation are detected.

Water-year total precipitation and 10-yr moving average

## CO Statewide Annual (water year) Temperatures, 1896-2009

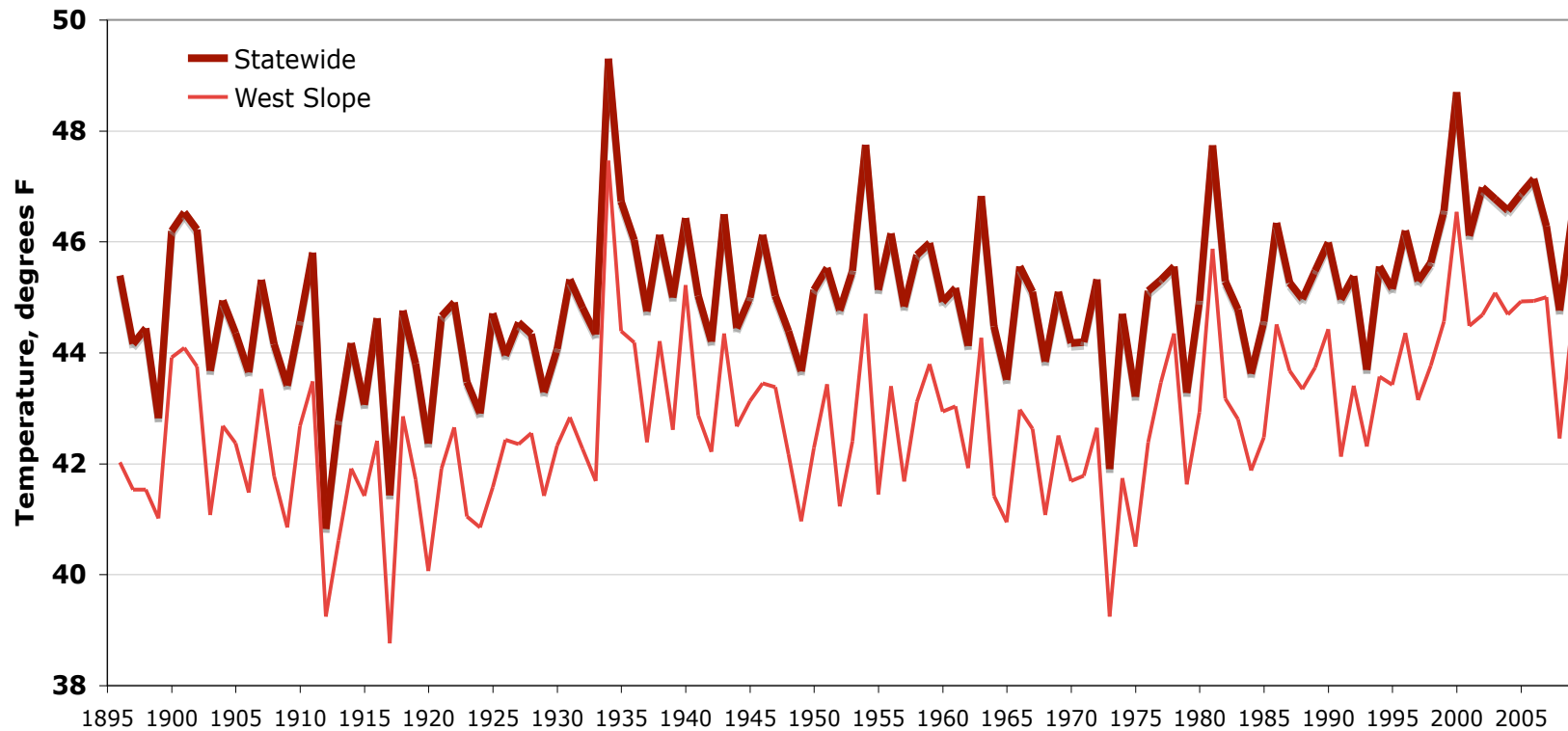


Year-to-year variability in temperatures relatively small (1-2 degrees)

Large decadal-scale variability

Warming of ~2 degrees F since 1970s

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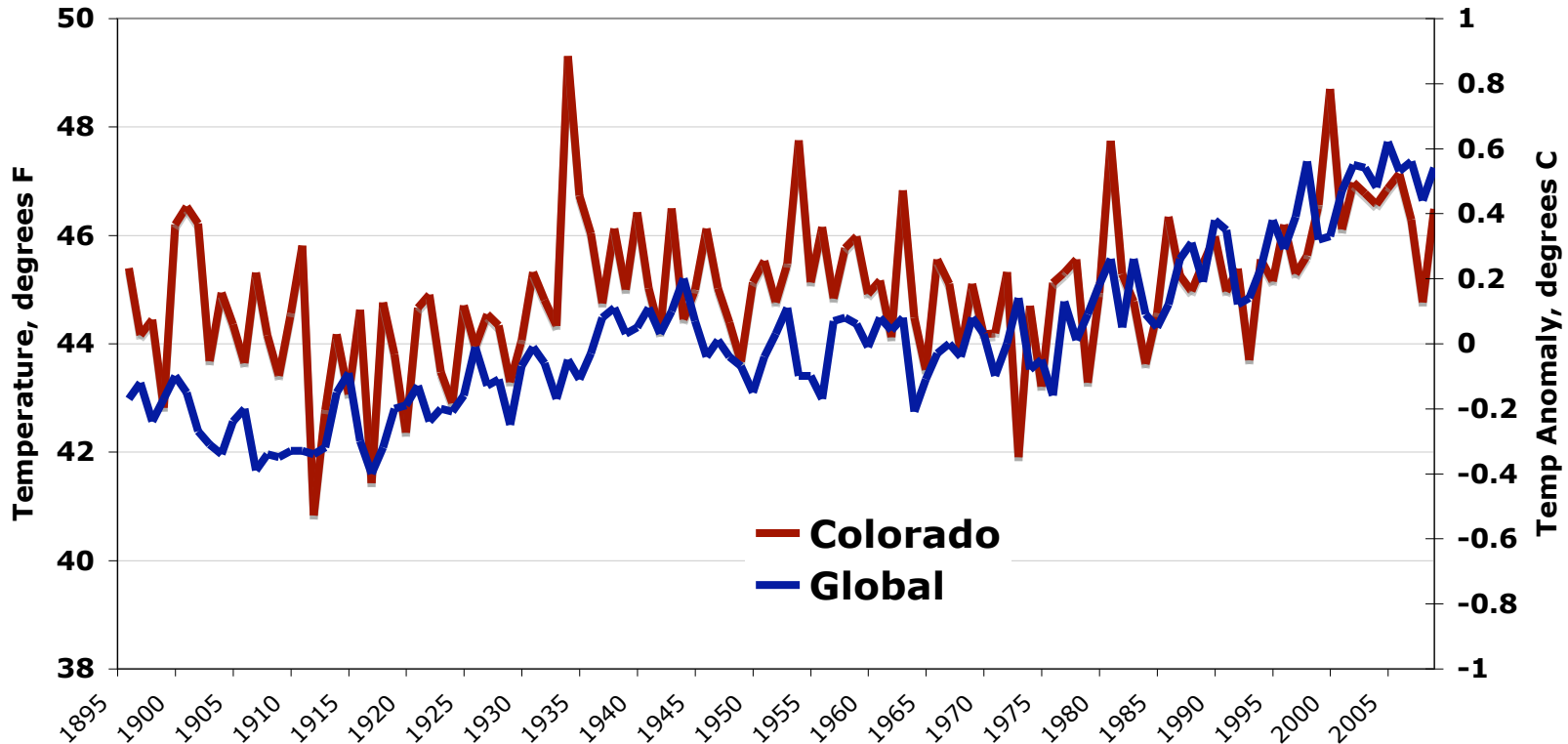
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## Sources of temperature variability

- Year-to-year: wetter years tend to be cooler and drier years tend to be warmer
  - Less solar input when cloudy/raining, and also cold-air intrusion is associated with precip-generating storms in most seasons
  - Dry soil heats up faster than wet soil, leading to (even) higher temperatures during drought
- Decadal variability mainly reflects changes in global heat budget

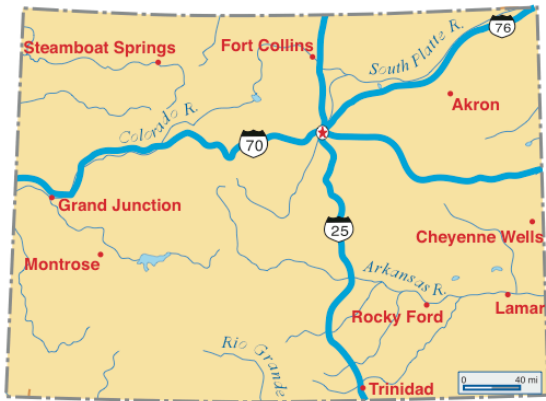
## CO vs. Global temperature variability, 1896-2008



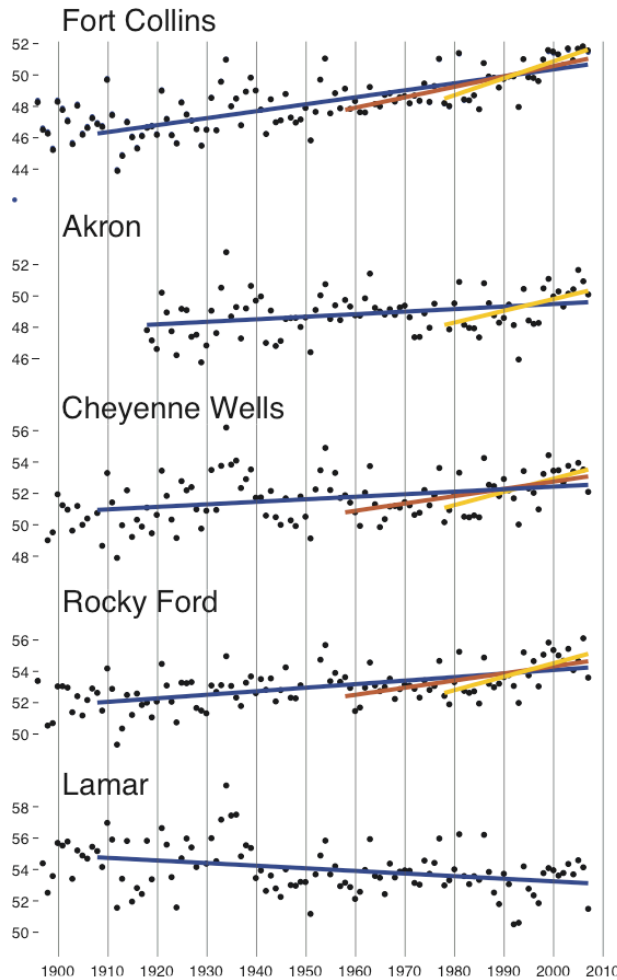
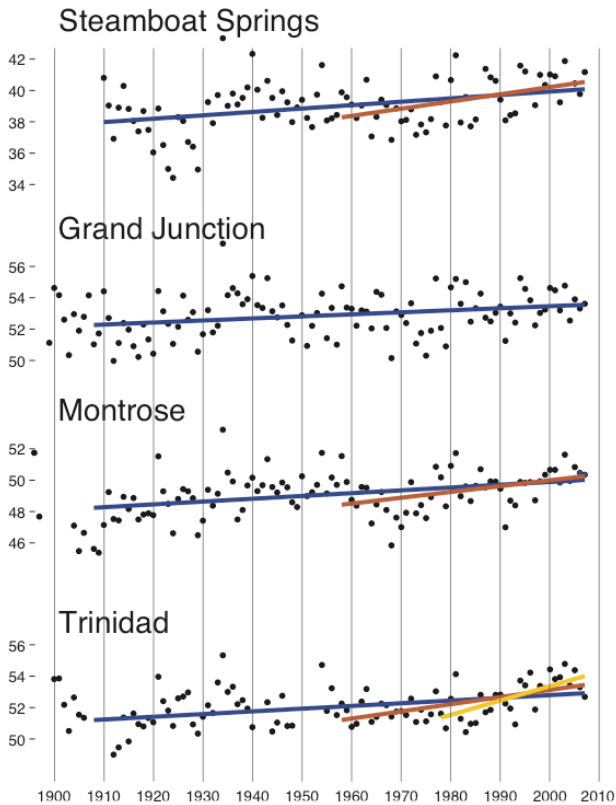
Decadal trends very are similar

*NOTE:* Colorado scale condensed 3x for comparison -  
so recent warming in CO is much greater than global

# Observations: 9-Station Temperature Trends



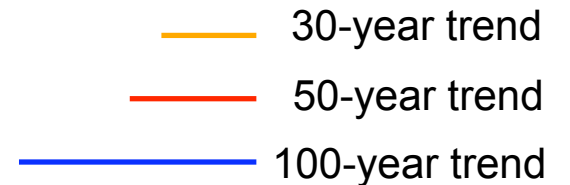
Source: CO Climate Report, 2008



Of 27 temperature trends:

- 19 are increasing
- 1 is decreasing
- 7 were not significant

Trends vary by region of the state, but most are **increasing** and significant



## Recap

- Weather and climate variability occurs on a wide range of time scales
- Colorado's precipitation is highly variable from year to year, but no long-term trends
- ENSO is an important “nudge” on storm tracks and year-to-year variability in Colorado, but much of the variability is random
- Temperature trends (warming) have been detected in the statewide average and in many parts of Colorado, matching global trends